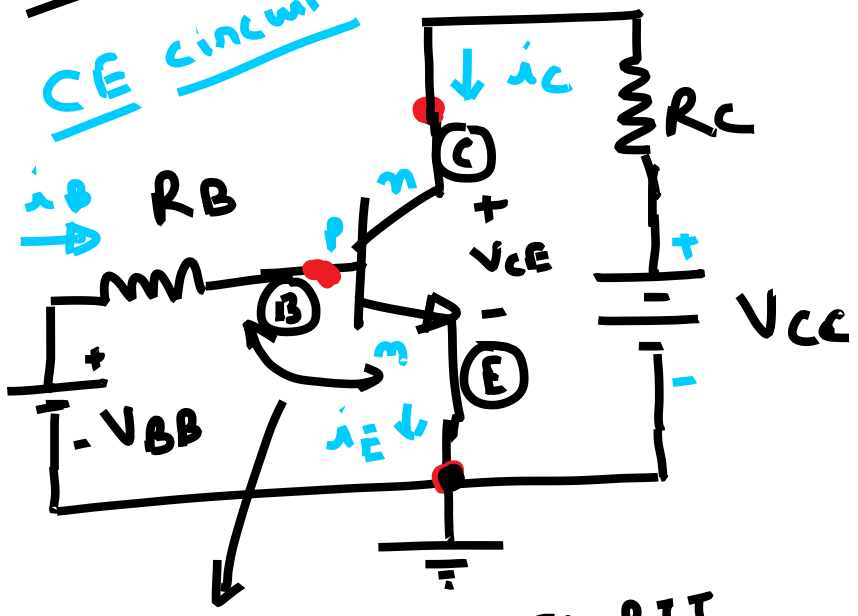
Bipolar Junction Transistor (BJT)

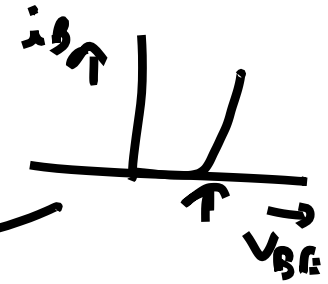
DC analysis

CE circuit



$V_{BE.ON} \approx 0.7V$ Si BJT

$$i_B = \frac{V_{BB} - V_{BE.ON}}{R_B} = \frac{V_{BB} - 0.7}{R_B}$$



✓ $V_{BB} > V_{BE.ON}$, BJT is ON, i_B finite

$V_{BB} < V_{BE.ON}$, BJT is OFF, $i_B = 0$.

$i_C = \beta i_B$ (forward active mode)

$V_{CE} = V_{CC} - i_C R_C$

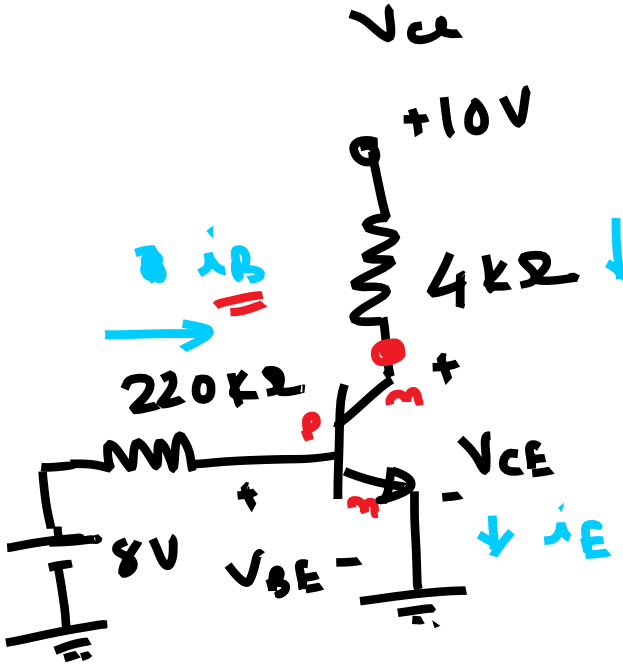
$V_{CE} > V_{BE.ON}$, B-C junction is in reverse bias.

Power dissipation in BJT $(P_T) = i_B V_{BE} + i_C V_{CE}$; $i_B \ll i_C$

$P_T \approx i_C V_{CE}$.

$V_{CE(Sat)} \rightarrow$ 0.1V to 0.3V

Bipolar Junction Transistor (BJT)



Given, $\beta = 100$, Si BJT, $V_{BE\_ON} = 0.7\,V$.

$V_{CE}(Sat) = 0.2\,V$.

Assume, BJT is in active region. ✗

$$i_B = \frac{8 - 0.7}{220\,K} = 33.2\,\mu A.$$ ✓

$$i_C = \beta i_B = 100 \times 33.2\,\mu A = 3.32\,mA.$$

$$V_{CE} = V_{cc} - i_C R_C = 10 - 3.32 \times 4 = -3.28\,V$$

$V_{CE} \not< 0$

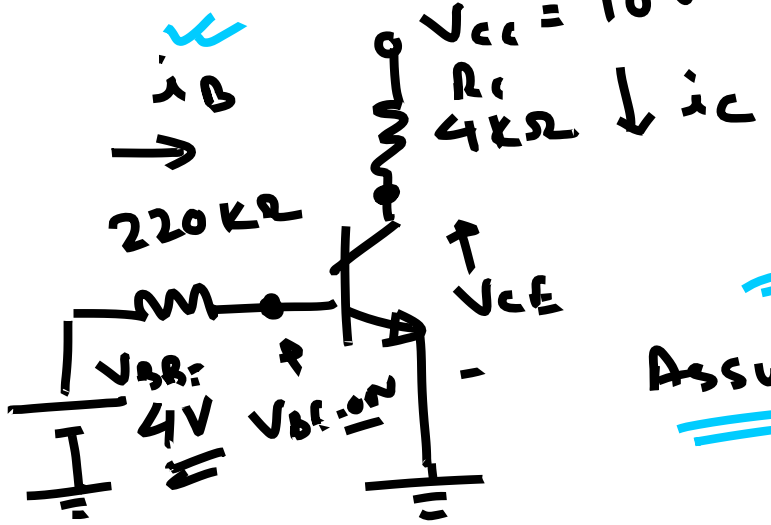
Saturation region.

$$i_C = \frac{10 - 0.2}{4K} = 2.45\,mA$$

$$\beta' = \frac{I_C}{I_B} = \frac{2.45\,mA}{33.2\,\mu A} \approx 74 < \beta\,(given)$$

Bipolar Junction Transistor (BJT)

$\beta = 100$, $V_{BE\_ON} = 0.7$, $V_{CE(SAT)} = 0.2V$.



$V_{BB} > V_{BE\_ON}$

$i_B = \frac{4 - 0.7}{220K} \approx 15\,\mu A$.

$i_B < 0$, cut-off.

Assume, active region operation.

$i_C = \beta i_B = 100 \times 15\,\mu A = 1.5\,mA$.

$V_{CE} = V_{CC} - i_C R_C = 10 - 1.5 \times 4K$

$V_{CE} = 4V$

Sat

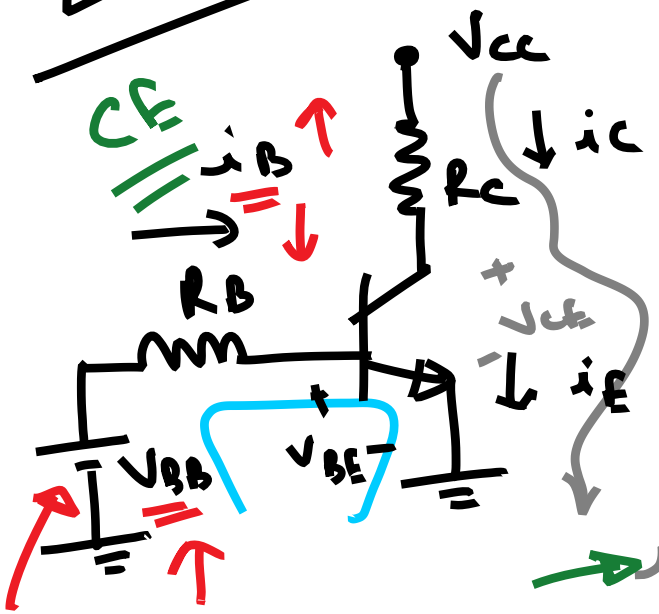
$V_{CE} < 0V$.

$P_T = i_C \cdot V_{CE} = 1.5\,mA \times 4V \rightarrow ??$

$= 6\,mW$.

Bipolar Junction Transistor (BJT)

Load line

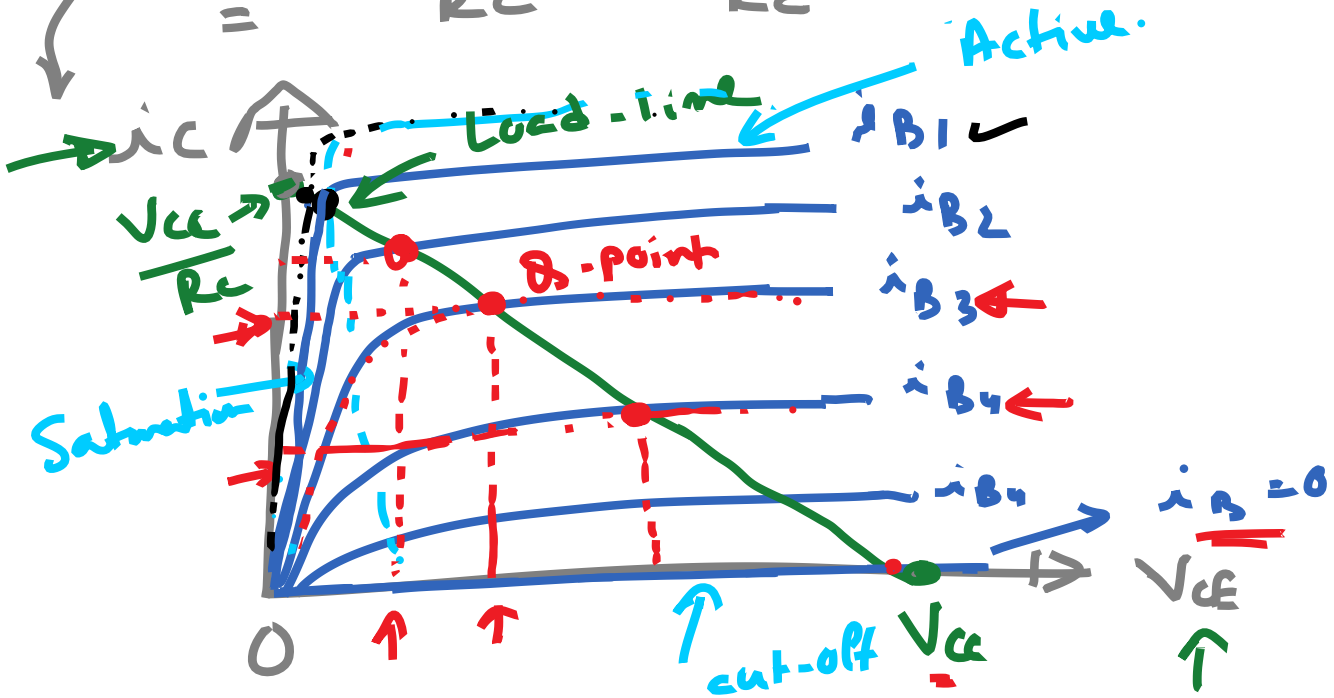


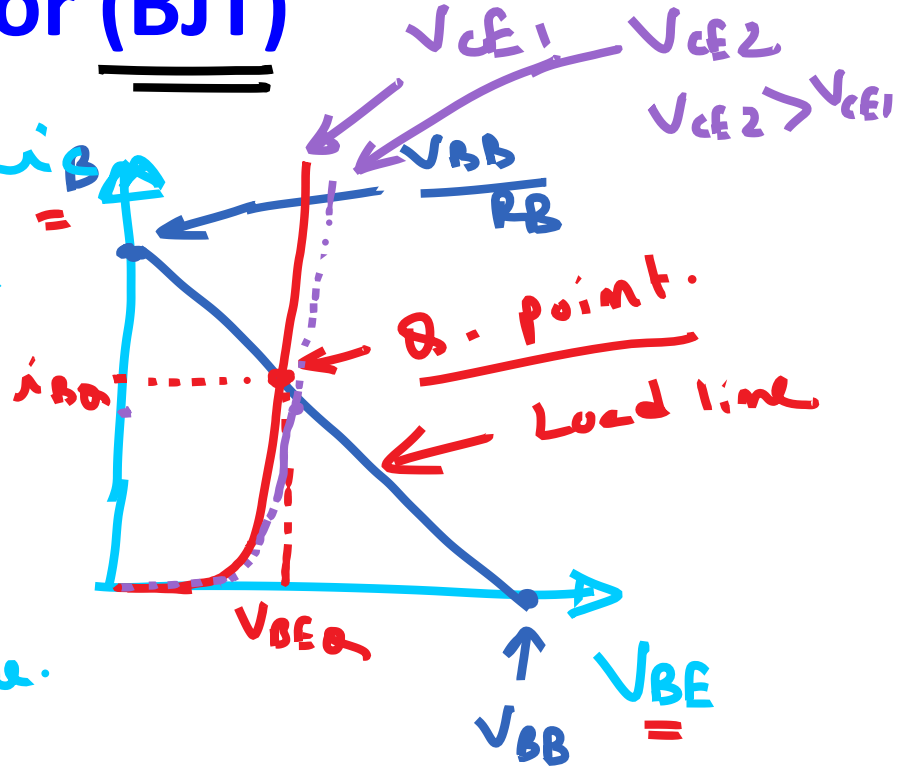
$$V_{BB} = i_B R_B + V_{BE}$$

$$i_B = \frac{V_{BB}}{R_B} - \frac{V_{BE}}{R_B}$$

$$V_{CC} = i_C R_C + V_{CE}$$

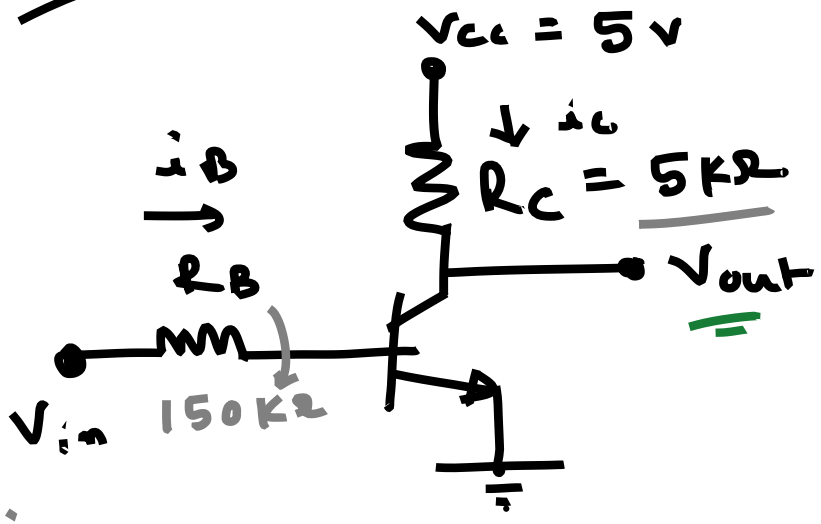
$$i_C = \frac{V_{CC}}{R_C} - \frac{V_{CE}}{R_C}$$





Bipolar Junction Transistor (BJT)

Voltage Transfer Characteristics (VTC)



$V_{BE\_ON} = 0.7$

$\beta = 120$

$V_{CE(Sat)} = 0.2\,V$

$V_A = \infty$

(I) $V_{in} < 0.7\,V$ — Cut-off

$i_B = i_C = 0$

$V_{out} = 5\,V$

(II) $V_{in} > 0.7\,V$, active region $\quad i_C = \beta i_B$

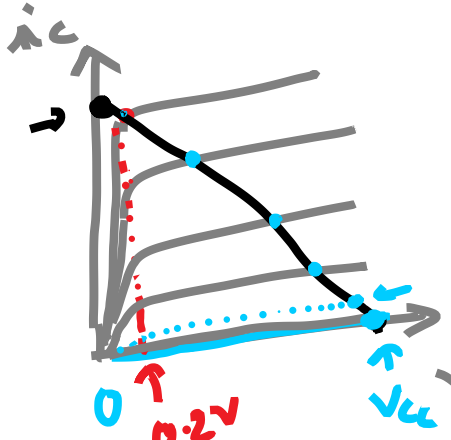
$$i_B = \frac{V_{in} - V_{BE\,ON}}{R_B}$$

$$i_C = \beta i_B$$

$$i_C = \frac{120\,(V_{in} - 0.7)}{R_B}$$

$$V_{out} = V_{cc} - i_C R_C$$

$$V_{out} = V_{cc} - \frac{120\,(V_{in} - 0.7)}{R_B} \cdot R_C$$

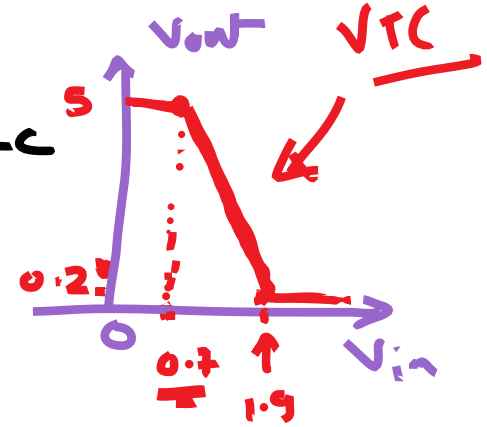


$V_{in} > 1.9\,V$ → saturation region

$V_{out} = V_{CE(sat)} = 0.2\,V$

$$0.2 = V_{cc} - \frac{120\,(V_{in} - 0.7)}{R_B} \cdot R_C$$

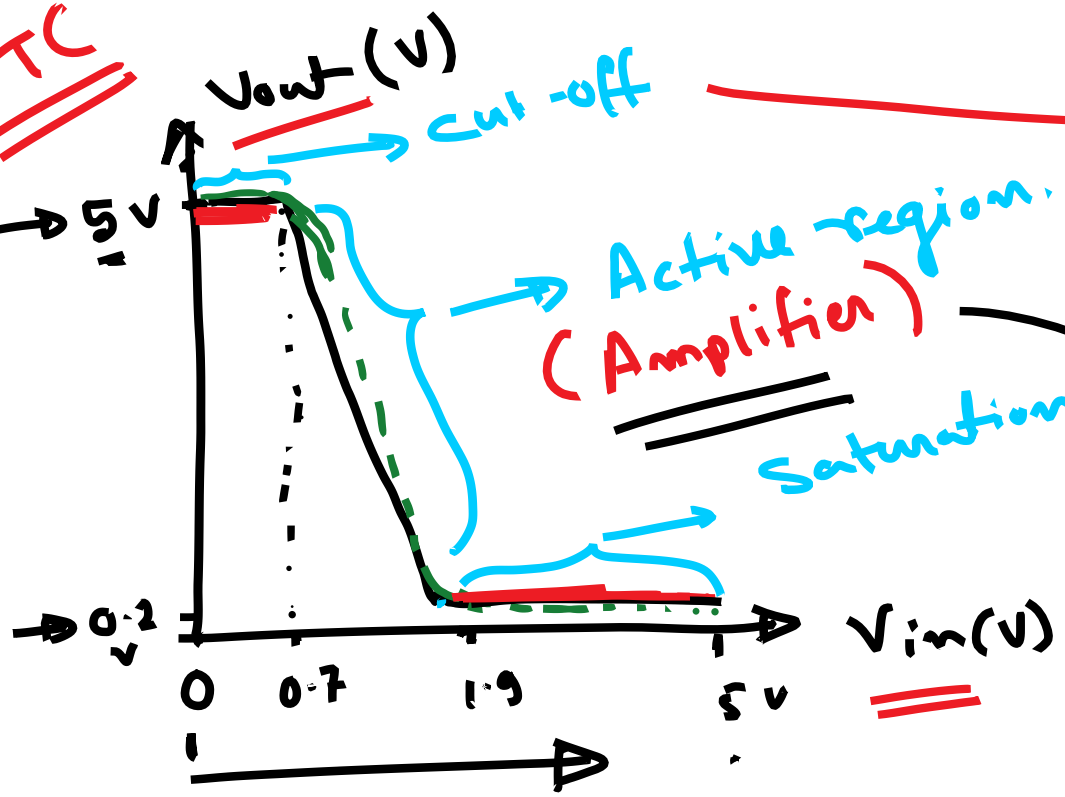
$V_{in} = 1.9\,V$ → Active region



Bipolar Junction Transistor (BJT)

CE

VTC



Switch.

Digital gate

NOT
NAND
NOR
} gates.

Amplifier.